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# COD LIVER OIL FOR LAYING PULLETS

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# BULLETIN NO. 337

(Research Bulletin)

## Cod Liver Oil for Laying Pullets

By J. HOLMES MARTIN and W. M. INSKO, JR.

In recent years the soil of many poultry ranges has become infested with internal parasites or the germs of disease, making it necessary to confine layers to poultry houses. Confinement has also been recommended in states where the winters are severe. Prohibiting birds from coming in contact with the soil, from pasturing on growing grass and from receiving direct sunlight has thrust upon poultry husbandry a number of vital problems, especially those concerned with the addition of vitamin D supplements to the ration and their effects on production, size, fertility and hatchability of the eggs.

Hughes, Payne and Latshaw(1) found that ultra-violet irradiation for ten minutes daily produced a marked increase in production and hatchability. They also reported that the average weight of calcium in the shell and the percentages of calcium and phosphorus in the white and yolk were larger in the eggs from irradiated confined hens than in those from non-irradiated confined hens.

Hart and coworkers(2) found that hens which received ultra-violet irradiation for ten minutes daily continued to lay abundantly, while the production of the hens not receiving irradiation dropped practically to zero. While the calcium and phosphorus content of the whites and yolks of the eggs from the two groups was not distinctly different, the amount of lime in the egg shell was noticeably increased by irradiation. Irradiation of the hens also greatly improved the hatchability of the eggs.

Holmes and associates(3, 4) reported that cod liver oil increased production and hatchability and also increased the vitamin A potency of the egg yolks.

Bethke and Kennard(5) found that when skimmilk, alfalfa hay, sunlight, cod liver oil and bluegrass range were given as supplements to a control ration, birds given bluegrass range showed the most improvement in hatchability. They emphasized the fact "that for good hatchability of eggs neither direct sunlight, potent cod liver oil nor ultra-violet light proved effective unless supplemented by either green feed, a legume hay or milk".

Taylor and Martin(6) reported that the average percent of egg shell from pullets allowed bluegrass range was greater than from those confined with sunlight or irradiated thirty minutes daily. Martin and Insko(7) and Martin, Erikson and Insko(8) found that hens receiving cod liver oil, irradiation, sunshine or bluegrass range, when compared with confined hens, all gave increased hatchability of pullet and hen eggs.

Wheeler(9) found that if hens were given access to open sunlight at ten or twenty day intervals, after the winter months, or allowed free access to reflected sunlight, they were able to maintain good production thruout the laying season.

Morgan, Mitchell and Roderick(10) found that feeding cod liver oil to pullets which had access to open range, under the climatic conditions of South Carolina, tended to increase the breaking strength of the egg shells, the percent of egg shell and the percent of calcium carbonate in the shell. Morgan(11) also found that a significant positive correlation exists between the percent of shell of an egg and its breaking strength.

Stuart and Charles(12) found that cod liver meal tends to produce significantly higher hatchability than cod liver oil.

Hendricks, Lee and Godfrey(13) reported that feeding cod liver oil or administering ultra-violet irradiation to laying hens confined without access to direct sunlight or green feed increased egg production and the thickness of the egg shells. Both supplements also increased the weight and hatchability of the eggs. When cod liver oil was not included in the diet of the hens confined without access to sunlight, the addition of oyster shell increased egg production and thickness of shell. The all-mash

mixture fed to all the hens contained 1.8 percent, each, of ground limestone and steamed bone meal. The authors infer that, "Oyster shell either is a source of easily available mineral or contains a small amount of some factor which is present in cod liver oil".

Halpin, Holmes and Hart(14) found that opening windows on bright days was an effective method of utilizing the ultra-violet rays, in winter sunshine. When vitamin D in the form of cod liver oil, was added to the ration it made possible a high level of egg production, but hatchability of the eggs was somewhat more variable than that of eggs laid by hens irradiated daily with ultra-violet light.

Extensive experiments by Buckner, Martin and Peter (15, 16, 17, 18) showed that in the absence of a calcium carbonate supplement (limestone or oyster shell), the hatchability of fertile eggs was diminished, the percentage of infertile eggs was increased, fewer and smaller eggs were laid, the shells became lighter and the chicks weighed less.

Graham, Smith and McFarlane(19) reported that the addition of cod liver oil to a single protein supplement increased the egg production with all rations tested but much more with beef scrap and tankage than with milk and fish scrap. Cod liver oil also increased the hatching power of the eggs set. Birds housed in the feeding trials did not get the necessary amount of sunshine until there were at least two hundred hours per month.

## EXPERIMENTAL METHOD

This experiment was planned to test the effect of cod liver oil on egg production, size of egg and fertility and hatchability, when it was included in the ration of White Leghorn pullets(1) confined to the house, (2)allowed sunshine, and (3)allowed blue-grass range.

All pens received the following all-mash mixture fed dry in hoppers:

| | |
|---|---|
| Ground yellow corn | 650 pounds |
| Wheat bran | 100 pounds |

| | |
|---|---|
| Wheat middlings | 100 pounds |
| Meat scrap (50% protein) | 75 pounds |
| Dried buttermilk | 25 pounds |
| Finely ground limestone | 20 pounds |
| Steamed bone meal | 20 pounds |
| Salt | 10 pounds |

Coarsely ground limestone (approximately 99% $CaCO_3$) and water were also available to all pens at all times. The pens were treated as follows:

First pair. Confined to house, sunlight filtered thru common window glass.

Pen 1. No cod liver oil. Pen 2. Cod liver oil, 2 percent of the mash.

Second pair. Confined to house and wire-screened, wire-floored sun porch.

Pen 3. No cod liver oil. Pen 4. Cod liver oil, 2 percent of the mash.

Third pair. Allowed range of bluegrass yard.

Pen 5. No cod liver oil. Pen 6. Cod liver oil, 2 percent of the mash.

In the experiment of 1929-30, thirty White Leghorn pullets were put into each pen. In 1930-31 and 1931-32, twenty-five White Leghorn pullets were put into each. The pullets were selected so as to make the pens as nearly as possible equal in maturity, weight, vigor and ancestry. The pens were housed September 1, 1929; October 1, 1930; and October 1, 1931. The houses were identical in construction and orientation. As already explained, pens 3 and 4 had sun porches.

In 1929-30 and 1930-31, one cockerel was added to each pen at the beginning of the hatching season. Substitutions were made, if the males showed lack of vigor or if fertility was low. In 1931-32, cockerels were placed in each pen five days before eggs for incubation were to be saved, and remained during the time that eggs were saved for this purpose. They were then removed and placed in a holding pen with access to bluegrass range. The males were rotated among the pens.

In the experiment of 1929-30, six hatches were set. Eggs were saved January 7th to 18th, January 19th to 31st, March 1st to 12th, April 18th to 29th, April 30th to May 9th and May 10th to 19th. These eggs were not weighed. In 1930-31 and 1931-32, beginning in November and continuing thru June, all eggs produced during the first ten days of each month* were incubated. All eggs were weighed individually and were pedigree hatched. All eggs which appeared infertile before the candle were broken and examined for fertility.

## RESULTS AND DISCUSSION

### Egg Production

The average egg production (Table 1) is grouped for the winter and for the total experimental period. The winter period includes the months of November, December, January and February. The limits of each experimental period were as follows: September 1, 1929, to June 30, 1930; October 1, 1930, to September 30, 1931; October 1, 1931, to September 30, 1932.

TABLE 1. Average Egg Production.

| Pen No. | Treatment | 1929-1930 | | 1930-1931 | | 1931-32 | |
|---|---|---|---|---|---|---|---|
| | | Winter | 10 Mos. | Winter | Year | Winter | Year |
| 1. | Confined. No Supplement | 30.4 | 68.6 | 47.1 | 112.0 | 30.9 | 70.9 |
| 2. | Confined. 2% Cod Liver Oil | 47.0 | 115.1 | 55.3 | 156.2 | 46.3 | 149.2 |
| 3. | Sunshine. No Supplement | 43.6 | 113.1 | 59.0 | 172.2 | 33.3 | 132.2 |
| 4. | Sunshine. 2% Cod Liver Oil | 51.6 | 125.5 | 65.8 | 190.2 | 47.4 | 149.1 |
| 5. | Bluegrass range. No Supplement | 31.7 | 114.9 | 68.4 | 202.3 | 55.0 | 171.8 |
| 6. | Bluegrass range. 2% Cod Liver Oil | 45.2 | 127.6 | 68.3 | 202.5 | 61.2 | 158.3 |

When the pullets were confined, the addition of cod liver oil to the mash increased the average egg production each winter and year. The increased egg production for the winter period for each year was, in 1929-30, 16.6 eggs; 1930-31, 8.2 eggs; and 1931-32, 15.4 eggs per hen. Similar increases were obtained for

*Eggs laid by these hens later in the month were used in other branches of the study. See "The pH of Fresh and Storage Eggs." Ky. Exp. Sta. Bul. 335, and "The Iron and Copper Content of Egg Yolk," (in press).

the entire experimental period, when two percent cod liver oil was given to pullets which were confined. For the ten-months period, 1929-30, the increase was 46.5 eggs; for the year, 1930-31, 44.2 eggs; and for the year, 1931-32, 78.3 eggs per hen. It is thus apparent that when pullets are confined to the house with no direct sunshine except thru ordinary window glass, cod liver oil produces a decided increase in egg production.

When pullets were confined to the house and a wire screened, wire floored sun porch, the addition of cod liver oil to the mash increased average egg production, tho not so much as when the pullets received sunlight only thru window glass. The increased egg production per hen for the winter period was 8.0 eggs for the first year; 6.8 for the second; and 14.1 for the third. The increases obtained for the entire experimental period were, for the first year, 12.4; for the second, 18.0; and for the third, 16.9 eggs.

When pullets were allowed bluegrass range, the addition of cod liver oil increased egg production during two winter periods. The increase for the winter period of 1929-30 was 13.5 eggs and for that of 1931-32, 6.2 eggs. There was no increase in production for the winter period in 1930-31. The addition of cod liver oil increased production 12.7 eggs in the 10 months of 1929-30. In 1930-31, the average production was virtually the same in both pens, whereas in 1931-32 the average production for the pullets receiving cod liver oil was 13.5 eggs less than for those not receiving cod liver oil.

A comparison of all other pens with pen 1, which was confined and received no vitamin D supplement, shows that in every case, either for the winter or the year, there was a decided increase as a result of the addition of cod liver oil, sunshine, range or any combination of these supplements. During 1929-30, the average increase in production due to the addition of sunshine alone was 44.5 eggs, while that due to the addition of sunshine and bluegrass range was 46.3 eggs. In the 1930-31 season, the average increase for sunshine was 60.2 eggs, and for bluegrass range, 90.3 eggs. In the 1931-32 season, the pullets in pen 3 receiving sunshine produced an average of 61.3 eggs

more than those in pen 1, confined without a vitamin D supplement. The average increase for pen 5, on bluegrass range, was 100.9 eggs more than pen 1.

When the three pens receiving cod liver oil in the mash are compared, it is seen that the addition of sunshine or bluegrass range increased production in every case but one, pen 4. In the 1929-30 season of ten months, the increase in production of pen 4 over pen 2 was 10.4 eggs; in 1930-31, the increase was 34.0 eggs, and in 1931-32, the production was the same. The increase in production for pen 6 which received cod liver oil in addition to bluegrass range, over pen 2 was 12.5 eggs for the first year (10 months), 46.3 eggs for the second, and 9.1 eggs for the third.

The average monthly egg production and the total number of hours of sunshine* per month are given in Table 2. The data presented further bear out the comparisons of production as shown by Table 1. Pens 5 and 6 which were allowed bluegrass range, produced their maximum number of eggs each year in either April or May. The pens confined but receiving sunshine reached a peak in March or April each year. Pen 2, without direct sunshine but receiving cod liver oil, reached a maximum in March or April. In 1929-30, pen 1 which was confined without a vitamin D supplement produced the largest number of eggs in March; in 1930-31, in January, and in 1931-32, in November.

### Egg Weight

Eggs produced during the first ten days of each month, from November thru June, were weighed and set on the eleventh day of each month. Altho evaporation introduces a small error, sufficient numbers are represented to give comparable figures for each pen.

As has been stated previously, Buckner, Martin and Peter (*loc. cit.*) found that the absence of a calcium carbonate supplement caused the production of fewer and smaller eggs. Hendricks, Lee and Godfrey (*loc. cit.*) reported that feeding cod liver oil or administering ultra-violet light to laying hens, which

*Sunshine data supplied by G. B. Wurtz, Meteorologist, U. S. Weather Bureau.

TABLE 2. Average Monthly Production and Total Sunshine.

| 1929-30 | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pen 1 | 2.3 | 5.8 | 7.3 | 7.8 | 9.5 | 10.4 | 9.0 | 7.3 | 5.2 | ..... | ..... | 4.0 | 68.6 |
| Pen 2 | 3.9 | 7.7 | 10.5 | 14.7 | 14.1 | 17.6 | 16.8 | 13.4 | 11.8 | ..... | ..... | 4.6 | 115.1 |
| Pen 3 | 2.8 | 4.9 | 9.6 | 13.2 | 15.9 | 20.1 | 18.0 | 13.8 | 11.5 | ..... | ..... | 3.3 | 113.1 |
| Pen 4 | 6.2 | 11.3 | 14.8 | 13.5 | 12.0 | 15.7 | 15.9 | 15.7 | 16.2 | ..... | ..... | 4.2 | 125.5 |
| Pen 5 | 4.5 | 3.5 | 3.4 | 10.5 | 14.3 | 16.7 | 20.4 | 20.5 | 17.9 | ..... | ..... | 3.2 | 114.9 |
| Pen 6 | 2.0 | 4.5 | 8.6 | 16.7 | 15.4 | 20.9 | 21.2 | 20.1 | 14.9 | ..... | ..... | 3.3 | 127.6 |
| Sunshine. Hrs. | 134.1 | 80.0 | 101.1 | 110.7 | 138.6 | 194.8 | 264.5 | 259.3 | 327.2 | ..... | ..... | (1)200.0 | |
| 1930-31 | | | | | | | | | | | | | |
| Pen 1 | 7.0 | 11.5 | 13.2 | 14.0 | 9.0 | 10.1 | 13.7 | 12.7 | 9.5 | 5.1 | 3.8 | 2.4 | 112.0 |
| Pen 2 | 7.1 | 12.5 | 14.4 | 16.2 | 12.[illegible] | 18.8 | 18.7 | 14.9 | 11.8 | 10.6 | 9.7 | 9.2 | 156.2 |
| Pen 3 | 7.6 | 13.9 | 15.0 | 15.3 | 14.8 | 16.6 | 18.8 | 18.1 | 18.0 | 14.0 | 11.3 | 8.8 | 172.2 |
| Pen 4 | 7.9 | 15.2 | 16.4 | 17.4 | 16.8 | 20.4 | 18.8 | 18.1 | 16.0 | 15.7 | 14.0 | 13.5 | 190.2 |
| Pen 5 | 7.6 | 16.4 | 17.5 | 17.5 | 17.[illegible] | 20.2 | 22.8 | 22.2 | 18.5 | 15.8 | 16.0 | 10.8 | 202.3 |
| Pen 6 | 9.0 | 16.0 | 15.5 | 18.7 | 18.2 | 22.3 | 22.4 | 21.4 | 18.9 | 16.4 | 14.1 | 9.6 | 202.5 |
| Sunshine. Hrs. | 204.6 | 148.9 | 120.1 | 128.4 | 121.[illegible] | 107.3 | 230.6 | 212.3 | 279.6 | 300.0 | 191.5 | 266.7 | |
| 1931-32 | | | | | | | | | | | | | |
| Pen 1 | 9.9 | 10.0 | 8.0 | 6.3 | 6.6 | 5.9 | 6.3 | 5.3 | 5.6 | 3.5 | 2.6 | 0.9 | 70.9 |
| Pen 2 | 11.6 | 12.0 | 9.3 | 10.4 | 14.6 | 16.2 | 16.7 | 16.4 | 15.2 | 10.8 | 10.3 | 5.7 | 149.2 |
| Pen 3 | 9.2 | 7.4 | 9.0 | 7.0 | 9.9 | 13.1 | 17.1 | 16.8 | 14.1 | 11.5 | 11.0 | 6.1 | 132.2 |
| Pen 4 | 12.9 | 10.9 | 12.7 | 13.5 | 10.3 | 16.0 | 14.8 | 15.7 | 11.1 | 12.9 | 10.4 | 7.9 | 149.1 |
| Pen 5 | 12.3 | 9.3 | 13.4 | 15.1 | 17.2 | 19.5 | 20.3 | 19.1 | 12.3 | 11.8 | 12.1 | 9.4 | 171.8 |
| Pen 6 | 12.5 | 11.9 | 16.4 | 16.6 | 16.3 | 16.9 | 18.2 | 16.6 | 12.8 | 7.5 | 7.0 | 5.6 | 158.3 |
| Sunshine. Hrs. | 195.8 | 126.6 | 60.3 | 103.7 | 167.[illegible] | 164.5 | 208.3 | 318.1 | 264.0 | 327.1 | 289.7 | 232.7 | |

(1) Sept., 1929.

were confined without access to direct sunlight or green feed, gave indication of a tendency to increase egg weight.

Atwood(20) reported that a study of 188 Single Comb White Leghorn pullets showed that, with few exceptions, the average size of the eggs increased from the beginning of the year to its close. Maw and Maw(21) found that there was a gradual increase in the weight of the eggs laid by pullets to the end of the first year. In addition, they found that weighing the first ten eggs laid in the fifth month gave a reliable estimate of the mean annual egg weight. Hays(22), however, found that maximum egg weight as well as standard egg weight appeared, on the average, during the fourth laying month. Recent experimental results reported by Bennion and Warren(23) show that "the mean weekly egg weight when compared with the weekly temperature showed a sharp decline when the temperature was above 85 degrees F." They say further, "that a dependable measure of an individual's maximum egg size can be attained by weighing the first ten eggs produced in April.

The average monthly egg weight for each pen for the seasons of 1930-31 and 1931-32 is given in Table 3. With the exception of pen 2, the average weight of the eggs in each pen for 1930-31, reached a maximum in March. A comparison with the monthly production given in Table 2 shows that this is the sixth month of production, but that the production for the first month (October) was low. Comparison of the various lots in the experiment shows that each pen started with a low average weight, gradually attained a maximum weight and during the next three months the average became appreciably lower.

It is interesting to note that in every case the mean egg weight for all eggs laid (November thru June) was slightly lower in the pens receiving cod liver oil, which is in disagreement with the findings of Hendricks, Lee and Godfrey (*loc. cit.*) A comparison of the total number of eggs weighed is made in Table 5 which also gives the hatchability of these eggs. Nearly twice as many eggs were set from pen 2 as from pen 1. Altho the addi-

tion of cod liver oil in this case increased egg production, it did not increase the mean egg weight.

TABLE 3. Average Weight of Eggs First 10 Days of Each Month

| Pen | Treatment | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | Avg. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1930-31 | | | | | | | | | |
| 1 | Confined. No supplement | 49.0 | 45.0 | 54.8 | 54.1 | 55.3 | 53.8 | 53.1 | 52.7 | 53.4 |
| 2 | Confined. 2% cod liver oil | 48.3 | 51.2 | 54.3 | 52.8 | 53.7 | 52.8 | 51.4 | 49.3 | 52.1 |
| 3 | Sunshine. No suppplement | 48.4 | 51.8 | 54.9 | 55.3 | 55.8 | 54.3 | 53.5 | 53.7 | 53.5 |
| 4 | Sunshine. 2% cod liver oil | 47.0 | 50.3 | 51.7 | 52.7 | 53.5 | 52.3 | 50.8 | 50.8 | 50.6 |
| 5 | Bluegrass range. No supplement | 49.4 | 50.9 | 53.8 | 55.3 | 55.7 | 55.2 | 53.2 | 52.7 | 52.5 |
| 6 | Bluegrass range. 2% cod liver oil | 46.7 | 48.7 | 52.2 | 53.2 | 54.7 | 53.1 | 52.7 | 51.2 | 52.0 |
| | Maximum temperature | 77 | 54 | 60 | 62 | 62 | 81 | 88 | 96 | |
| | 1931-32 | | | | | | | | | |
| 1 | Confined. No supplement | 51.2 | 53.1 | 53.1 | 53.1 | 52.7 | 51.7 | 50.2 | 49.0 | 51.9 |
| 2 | Confined. 2% cod liver oil | 50.3 | 51.0 | 52.4 | 52.8 | 53.7 | 52.4 | 50.4 | 49.7 | 51.7 |
| 3 | Sunshine. No supplement | 49.5 | 51.2 | 54.7 | 54.2 | 54.7 | 54.0 | 52.4 | 52.2 | 52.9 |
| 4 | Sunshine. 2% cod liver oil | 49.3 | 50.2 | 52.6 | 53.4 | 53.4 | 53.8 | 50.9 | 48.4 | 51.6 |
| 5 | Bluegrass range. No supplement | 48.4 | 50.7 | 51.4 | 52.9 | 53.6 | 52.2 | 50.6 | 50.8 | 51.7 |
| 6 | Bluegrass range. 2% cod liver oil | 48.3 | 51.4 | 52.6 | 52.7 | 53.0 | 51.1 | 51.1 | 50.1 | 51.5 |
| | Maximum temperature | 76 | 66 | 68 | 75 | 71 | 78 | 84 | 89 | |

A comparison of maximum temperature and average egg weight shows that in April, May and June the maximum temperature was above 81° F. and egg weight decreased. This effect of maximum temperature on egg weight is in agreement with results of Bennion and Warren (*loc. cit.*) who studied the egg weight of individual hens.

### Fertility and Hatchability

The vitamin D content of the ration exerts a profound influence on hatchability. A summary of these data is given in Tables 4, 5, 6 and 7 and Figure 1.

A study of the data for the 1929-30 hatching season shows that the addition of cod liver oil to the mash, when the birds were confined, increased the fertility 5.1 percent, but that the

addition of cod liver oil to the mash when the birds received sunshine, did not increase fertility, in fact the fertility was 5.3 percent less than in the pen receiving sunshine but no range. The

Fig. 1. Average hatchability for season.

pen allowed bluegrass range had 12.0 percent higher fertility than the confined pen which received no vitamin D supplement and the pen receiving bluegrass range and cod liver oil had an increased fertility of 9.8 percent when compared with the confined pen. The addition of cod liver oil to the mash when the birds were allowed bluegrass range did not improve fertility.

During the 1930-31 season, the addition of cod liver oil to the mash of confined birds increased the fertility 21.6 percent, whereas the addition of sunshine increased fertility 16.4 percent above that of the confined pen. Cod liver oil and sunshine increased fertility above that of the confined pen 26.8 percent. The addition of cod liver oil when the birds received sunshine increased the fertility 10.4 percent. When bluegrass range was available, fertility was 22.7 percent higher than in the confined pen. Cod liver oil and bluegrass range increased the fertility over that of the confined pen 31.2 percent. The addition of cod

TABLE 4. Hatchability* and Fertility 1929-30.

| Pen and Item | Jan. 7-18 | Jan. 19-31 | Mar. 1-12 | Apr. 18-29 | Apr. 30-May 9 | May 10-19 | Summary |
|---|---|---|---|---|---|---|---|
| Pen 1. Confined. No supplement | | | | | | | |
| Total eggs set | 90 | 57 | 67 | 41 | 44 | 45 | 344 |
| Fertile eggs, percent | 86.0 | 66.7 | 89.6 | 70.7 | 84.1 | 77.8 | 80.2 |
| Chicks hatched | 44 | 23 | 22 | 7 | 8 | 5 | 109 |
| Fertile eggs hatched, percent | 57.1 | 60.5 | 36.7 | 24.1 | 21.6 | 14.3 | 39.5 |
| Total eggs hatched, percent | 48.9 | 40.4 | 32.8 | 17.1 | 18.2 | 11.1 | 31.7 |
| Pen 2. Confined. 2% cod liver oil | | | | | | | |
| Total eggs set | 129 | 119 | 120 | 106 | 84 | 73 | 631 |
| Fertile eggs, percent | 86.8 | 87.4 | 94.2 | 74.5 | 80.0 | 86.3 | 85.3 |
| Chicks hatched | 90 | 72 | 63 | 35 | 30 | 38 | 328 |
| Fertile eggs hatched, percent | 80.4 | 69.2 | 55.8 | 44.3 | 44.8 | 60.3 | 61.0 |
| Total eggs hatched, percent | 69.8 | 60.5 | 52.5 | 33.0 | 35.7 | 52.1 | 52.0 |
| Pen 3. Sunshine. No. supplement | | | | | | | |
| Total eggs set | 108 | 86 | 117 | 82 | 70 | 47 | 510 |
| Fertile eggs, percent | 81.5 | 72.1 | 83.8 | 74.4 | 75.7 | 97.9 | 80.0 |
| Chicks hatched | 61 | 54 | 64 | 27 | 28 | 33 | 267 |
| Fertile eggs hatched, percent | 69.3 | 87.1 | 65.3 | 44.3 | 52.8 | 71.7 | 65.4 |
| Total eggs hatched, percent | 56.5 | 62.8 | 54.7 | 32.9 | 40.0 | 70.2 | 52.4 |
| Pen 4. Sunshine. 2% cod liver oil | | | | | | | |
| Total eggs set | 144 | 108 | 123 | 94 | 79 | 73 | 621 |
| Fertile eggs, percent | 72.9 | 76.9 | 87.8 | 72.3 | 67.1 | 64.4 | 74.7 |
| Chicks hatched | 70 | 61 | 51 | 33 | 28 | 26 | 269 |
| Fertile eggs hatched, percent | 66.7 | 73.5 | 47.2 | 48.5 | 52.8 | 55.3 | 58.0 |
| Total eggs hatched, percent | 48.6 | 56.5 | 41.5 | 35.1 | 35.4 | 35.6 | 43.3 |
| Pen 5. Bluegrass range. No supplement | | | | | | | |
| Total eggs set | 77 | 85 | 85 | 86 | 77 | 88 | 498 |
| Fertile eggs, percent | 96.1 | 87.1 | 95.3 | 93.0 | 87.0 | 94.3 | 92.2 |
| Chicks hatched | 58 | 59 | 54 | 40 | 39 | 67 | 317 |
| Fertile eggs hatched, percent | 78.4 | 79.7 | 66.7 | 50.0 | 58.2 | 80.7 | 69.1 |
| Total eggs hatched, percent | 75.3 | 69.4 | 63.5 | 46.5 | 50.6 | 76.1 | 63.7 |
| Pen 6. Bluegrass range. 2% cod liver oil | | | | | | | |
| Total eggs set | 165 | 158 | 151 | 159 | 134 | 121 | 888 |
| Fertile eggs, percent | 86.1 | 84.8 | 96.0 | 88.1 | 91.0 | 95.9 | 90.0 |
| Chicks hatched | 116 | 110 | 112 | 92 | 81 | 95 | 606 |
| Fertile eggs hatched, percent | 81.7 | 82.1 | 77.2 | 65.7 | 66.4 | 81.9 | 75.8 |
| Total eggs hatched, percent | 70.3 | 69.6 | 74.2 | 57.9 | 60.4 | 78.5 | 68.2 |

*Hatchability refers to number of fertile eggs that hatch.

liver oil when the birds were allowed bluegrass range increased fertility 8.4 percent.

During the season of 1931-32, the addition of cod liver oil to the mash of confined pullets increased fertility 10.9 percent. The addition of sunshine alone when compared with confinement increased fertility only 4.0 percent, while sunshine and cod liver oil increased fertility 21.2 percent. Bluegrass range increased fertility 19.3 percent above that of the fertility of eggs from

TABLE 5. Hatchability and fertility 1930-31

| Pen and Item* | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | Summary |
|---|---|---|---|---|---|---|---|---|---|
| Pen 1. Confined. No supplement | | | | | | | | | |
| Total eggs set | 75 | 84 | 92 | 81 | 57 | 67 | | | 456 |
| Fertile eggs, percent | 89.3 | 83.3 | 25.0 | 74.1 | 59.6 | 61.2 | | | 64.7 |
| Chicks hatched | 32 | 5 | 11 | 22 | 5 | 5 | | | 108 |
| Fertile eggs hatched, percent | 47.8 | 47.1 | 47.8 | 36.7 | 14.7 | 12.2 | | | 36.7 |
| Total eggs hatched, percent | 42.7 | 39.3 | 12.0 | 27.2 | 8.8 | 7.5 | | | 23.7 |
| Pen 2. Confined. 2% cod liver oil | | | | | | | | | |
| Total eggs set | 73 | 94 | 115 | 105 | 115 | 138 | 119 | 67 | 826 |
| Fertile eggs, percent | 87.7 | 85.1 | 81.7 | 88.6 | 79.1 | 89.9 | 93.3 | 83.6 | 86.3 |
| Chicks hatched | 16 | 29 | 25 | 47 | 22 | 57 | 68 | 30 | 294 |
| Fertile eggs hatched, percent | 25.0 | 36.3 | 26.6 | 50.5 | 24.2 | 46.0 | 61.3 | 53.6 | 41.2 |
| Total eggs hatched, percent | 21.9 | 30.9 | 21.7 | 44.8 | 19.1 | 41.3 | 57.1 | 44.8 | 35.6 |
| Pen 3. Sunshine. No supplement | | | | | | | | | |
| Total eggs set | 98 | 104 | 108 | 117 | 125 | 133 | 121 | 118 | 924 |
| Fertile eggs, percent | 96.0 | 86.5 | 80.6 | 86.3 | 69.6 | 75.2 | 81.8 | 77.1 | 81.1 |
| Chicks hatched | 60 | 48 | 49 | 59 | 41 | 39 | 57 | 68 | 421 |
| Fertile eggs hatched, percent | 63.8 | 53.3 | 56.3 | 58.4 | 47.1 | 39.0 | 57.6 | 74.7 | 56.2 |
| Total eggs hatched, percent | 61.2 | 46.2 | 45.4 | 50.4 | 32.8 | 29.3 | 47.1 | 57.6 | 45.6 |
| Pen 4. Sunshine. 2% cod liver oil | | | | | | | | | |
| Total eggs set | 95 | 103 | 118 | 149 | 143 | 131 | 112 | 111 | 962 |
| Fertile eggs, percent | 90.5 | 93.2 | 95.8 | 91.3 | 92.3 | 89.3 | 89.3 | 90.1 | 91.5 |
| Chicks hatched | 37 | 48 | 69 | 96 | 87 | 77 | 73 | 81 | 568 |
| Fertile eggs hatched, percent | 43.0 | 50.0 | 61.1 | 70.6 | 65.9 | 65.8 | 73.0 | 81.0 | 64.5 |
| Total eggs hatched, percent | 38.9 | 46.6 | 58.5 | 64.4 | 60.8 | 58.8 | 65.2 | 73.0 | 59.0 |
| Pen 5. Bluegrass range. No supplement | | | | | | | | | |
| Total eggs set | 112 | 106 | 119 | 143 | 139 | 164 | 155 | 141 | 1079 |
| Fertile eggs, percent | 96.4 | 91.5 | 95.0 | 89.5 | 93.5 | 87.2 | 82.6 | 68.1 | 87.4 |
| Chicks hatched | 79 | 70 | 85 | 93 | 111 | 96 | 103 | 78 | 715 |
| Fertile eggs hatched percent | 73.1 | 72.2 | 75.2 | 72.7 | 85.4 | 67.1 | 80.5 | 81.3 | 75.8 |
| Total eggs hatched, percent | 70.5 | 66.0 | 71.4 | 65.0 | 79.9 | 58.5 | 66.5 | 55.3 | 66.3 |
| Pen 6. Bluegrass range. 2% cod liver oil | | | | | | | | | |
| Total eggs set | 113 | 105 | 139 | 137 | 145 | 161 | 150 | 109 | 1059 |
| Fertile eggs, percent | 97.3 | 97.1 | 92.8 | 97.8 | 98.6 | 95.7 | 93.3 | 93.6 | 95.8 |
| Chicks hatched | 61 | 48 | 61 | 92 | 117 | 65 | 109 | 74 | 627 |
| Fertile eggs hatched, percent | 55.5 | 47.1 | 47.3 | 68.7 | 81.8 | 42.2 | 77.9 | 72.5 | 61.8 |
| Total eggs hatched, percent | 54.0 | 45.7 | 43 9 | 67.2 | 80.7 | 40.4 | 72.7 | 67.9 | 59.2 |

*Eggs saved from 1st thru the 10th of each month.

TABLE 6. Hatchability and Fertility 1931-32.

| Pen and Item* | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | Summary |
|---|---|---|---|---|---|---|---|---|---|
| Pen 1. Confined. No supplement | | | | | | | | | |
| Total eggs set | 81 | 54 | 43 | 39 | 34 | 41 | 26 | 30 | 348 |
| Fertile eggs, percent | 9.9 | 92.6 | 93.0 | 53.8 | 76.5 | 82.9 | 53.8 | 56.7 | 60.3 |
| Chicks hatched | 7 | 36 | 19 | 10 | 14 | 15 | 7 | 7 | 115 |
| Fertile eggs hatched, percent | 87.5 | 72.0 | 47.5 | 47.6 | 53.8 | 44.1 | 50.0 | 41.2 | 54.8 |
| Total eggs hatched, percent | 8.6 | 66.7 | 44.2 | 25.6 | 41.2 | 36.6 | 26.9 | 23.3 | 33.0 |
| Pen. 2. Confined. 2% cod lived oil. | | | | | | | | | |
| Total eggs set | 82 | 67 | 67 | 105 | 119 | 121 | 100 | 106 | 767 |
| Fertile eggs, percent | 57.3 | 91.0 | 98.5 | 81.0 | 58.0 | 76.9 | 64.0 | 57.5 | 71.2 |
| Chicks hatched | 34 | 41 | 48 | 68 | 40 | 71 | 41 | 42 | 385 |
| Fertile eggs hatched, percent | 72.3 | 67.2 | 72.7 | 80.0 | 58.0 | 76.3 | 64.1 | 68.9 | 70.5 |
| Total eggs hatched, percent | 41.5 | 61.7 | 71.6 | 64.8 | 33.6 | 58.7 | 41.0 | 39.6 | 50.2 |
| Pen 3. Sunshine. No supplement | | | | | | | | | |
| Total eggs set | 38 | 45 | 48 | 54 | 71 | 99 | 85 | 75 | 515 |
| Fertile eggs, percent | 84.2 | 40.6 | 56.3 | 70.4 | 81.7 | 90.9 | 42.4 | 42.7 | 64.3 |
| Chicks hatched | 19 | 11 | 15 | 27 | 37 | 73 | 24 | 20 | 226 |
| Fertile eggs hatched, percent | 59.4 | 61.1 | 55.6 | 71.1 | 63.8 | 81.1 | 66.7 | 62.5 | 68.3 |
| Total eggs hatched, percent | 50.0 | 24.4 | 31.3 | 50.0 | 52.1 | 73.7 | 28.2 | 26.7 | 43.9 |
| Pen 4. Sunshine. 2% cod liver oil | | | | | | | | | |
| Total eggs set | 89 | 34 | 57 | 46 | 48 | 60 | 54 | 23 | 411 |
| Fertile eggs, percent | 73.0 | 100.0 | 75.4 | 82.6 | 85.4 | 75.0 | 98.1 | 69.6 | 81.5 |
| Chicks hatched | 45 | 23 | 24 | 31 | 23 | 36 | 37 | 10 | 229 |
| Fertile eggs hatched, percent | 69.2 | 67.6 | 55.8 | 81.6 | 56.1 | 80.0 | 69.8 | 62.5 | 68.4 |
| Total eggs hatched, percent | 50.6 | 67.6 | 42.1 | 67.4 | 47.9 | 60.0 | 68.5 | 43.5 | 55.7 |
| Pen 5. Bluegrass range. No supplement | | | | | | | | | |
| Total eggs set | 56 | 85 | 97 | 131 | 148 | 147 | 138 | 98 | 900 |
| Fertile eggs, percent | 89.3 | 74.1 | 88.7 | 74.0 | 81.1 | 81.6 | 79.0 | 72.4 | 79.6 |
| Chicks hatched | 43 | 52 | 68 | 77 | 88 | 85 | 87 | 57 | 555 |
| Fertile eggs hatched, percent | 86.0 | 89 | 76.7 | 79.4 | 73.3 | 70.8 | 79.8 | 80.3 | 77.5 |
| Total eggs hatched, percent | 76.8 | 61.2 | 68.0 | 58.8 | 59.5 | 57.8 | 63.0 | 58.2 | 61.7 |
| Pen 6. Bluegrass range. 2% cod liver oil | | | | | | | | | |
| Total eggs set | 63 | 116 | 125 | 123 | 131 | 130 | 103 | 96 | 887 |
| Fertile eggs, percent | 93.7 | 60.3 | 64.8 | 54.5 | 62.6 | 65.4 | 62.1 | 55.2 | 63.2 |
| Chicks hatched | 53 | 57 | 60 | 50 | 69 | 52 | 43 | 34 | 418 |
| Fertile eggs hatched, percent | 89.8 | 81.4 | 74.1 | 74.6 | 84.1 | 61.2 | 67.2 | 64.2 | 74.5 |
| Total eggs hatched, percent | 84.1 | 49.7 | 48.0 | 40.7 | 52.7 | 40.0 | 41.7 | 35.4 | 47.1 |

*Eggs saved from 1st thru the 10th of each month.

TABLE 7. Fertile Eggs Hatched, Percent.

| Eggs Saved | Without cod liver oil | | | With cod liver oil | | |
|---|---|---|---|---|---|---|
| | Pen 1 | Pen 3 | Pen 5 | Pen 2 | Pen 4 | Pen 6 |
| 1929-30 | | | | | | |
| January 7-18 | 57 | 69 | 78 | 80 | 67 | 82 |
| January 19-31 | 61 | 87 | 80 | 69 | 74 | 82 |
| March 1-12 | 37 | 65 | 67 | 56 | 47 | 77 |
| April 18-29 | 24 | 44 | 50 | 44 | 49 | 66 |
| April 30-May 9 | 22 | 53 | 58 | 45 | 53 | 66 |
| May 10-19 | 14 | 72 | 81 | 60 | 55 | 82 |
| Season summary | 40 | 65 | 69 | 61 | 58 | 76 |
| 1930-31 | | | | | | |
| November 1-10 | 48 | 64 | 73 | 25 | 43 | 56 |
| December 1-10 | 47 | 53 | 72 | 36 | 50 | 47 |
| January 1-10 | 48 | 56 | 75 | 27 | 61 | 47 |
| February 1-10 | 37 | 58 | 73 | 51 | 71 | 69 |
| March 1-10 | 15 | 47 | 85 | 24 | 66 | 82 |
| April 1-10 | 12 | 39 | 67 | 46 | 66 | 42 |
| May 1-10 | | 58 | 81 | 61 | 73 | 78 |
| June 1-10 | | 75 | 81 | 54 | 81 | 73 |
| Season's summary | 37 | 56 | 76 | 41 | 65 | 62 |
| 1931-32 | | | | | | |
| November 1-10 | 88 | 59 | 86 | 72 | 69 | 90 |
| December 1-10 | 72 | 61 | 83 | 67 | 68 | 81 |
| January 1-10 | 48 | 56 | 77 | 73 | 56 | 74 |
| February 1-10 | 48 | 71 | 79 | 80 | 82 | 75 |
| March 1-10 | 54 | 64 | 73 | 58 | 56 | 84 |
| April 1-10 | 44 | 81 | 71 | 76 | 80 | 61 |
| May 1-10 | 50 | 67 | 80 | 64 | 70 | 67 |
| June 1-10 | 41 | 63 | 80 | 69 | 63 | 64 |
| Season's summary | 55 | 68 | 78 | 71 | 68 | 75 |

birds confined without a vitamin D supplement. Bluegrass range and cod liver oil increased fertility only 2.9 percent above that of the confined pen.

The proportion of fertile eggs hatched for the season of 1929-30 (Table 7) in pen 1, confined without cod liver oil was 21 percent less than that of pen 2 confined, but receiving two percent cod liver oil in the mash. When the birds were confined cod liver oil in the mash gave an increase in hatchability for each period during the season. A comparison of hatchability in the confined pen receiving no vitamin D supplement with that of the pen which was given direct sunshine shows an increase of 25 percent in hatchability and a larger percentage hatchability during each period for the pen receiving sunshine. Altho the addition of cod liver oil and sunshine gave 18 percent greater hatchability than was secured from the confined pen and also higher hatch-

ability each period, there was a decrease of 7 percent when this pen was compared with the pens receiving sunshine only. The birds on bluegrass range gave 29 percent higher hatchability for the season than the confined pen but bluegrass range and cod liver oil gave 36 percent higher hatchability than the confined pen or 7 percent higher hatchability than the pen receiving bluegrass range.

During the season of 1930-31, the addition of cod liver oil to the mash when the birds were confined only increased the hatchability 4 percent, while sunshine caused an increase of 19 percent. The addition of cod liver oil to the mash when birds received sunshine caused a further increase of 9 percent in hatchability. Bluegrass range increased the hatchability when compared with the check pen (pen 1) 39 percent, but bluegrass range and cod liver oil increased hatchability only 25 percent or 14 percent less than the pen receiving bluegrass range without the cod liver oil.

During the 1931-32 hatching season, the hatchability of the eggs in the pens not receiving cod liver oil was improved 13 percent by sunshine and 23 percent by bluegrass range (above the hatchability in pen 1). In the pens receiving two percent cod liver oil in the mash, sunshine did not improve hatchability and bluegrass range improved hatchability only 4 percent above that of the confined pen receiving 4 percent of cod liver oil in the mash. When the birds were confined cod liver oil improved hatchability 16 percent, when they received sunshine cod liver oil did not improve hatchability and when they were allowed bluegrass range cod liver oil gave 3 percent lower hatchability.

A comparison of all lots in the experiment shows that in each of the three years, each of the vitamin D supplements increased hatchability above that of pen 1 which was confined without a vitamin D supplement. Best results were secured from bluegrass range and for one season bluegrass range supplemented with cod liver oil. It does not seem advisable to confine pullets either totally or partially, as is the case when wire screened porches are provided, if bluegrass range is available

unless the prevalence of intestinal parasites makes it necessary to allow the range to be idle for one or more years. It is advisable, as was done in this experiment, to provide alternate bluegrass yards so that there may be a rotation of range.

It has been pointed out by Martin, Erikson, Insko and Boyden(24) that hens which receive an adequate supply of vitamin D along with bluegrass pasture produce chicks which grow more rapidly, and that "It is possible that bluegrass pasture adds a factor to the ration which is not present in sunshine, irradiation or cod liver oil." The present experiment shows also that under the climatic conditions usually found in Kentucky during the hatching season, bluegrass range and sunshine provide ample supplements to the basal ration to assure high hatchability. If the winter is extremely cold with sudden changes in temperature or the total number of hours of sunshine is small, then cod liver oil gives good results when added to the mash of pullets which are allowed bluegrass range.

### Weight of Chicks

The average weight of all chicks hatched in each pen during the seasons of 1930-31 and 1931-32 is given in table 8. It will be seen that cod liver oil had little effect on the average weight of the chicks hatched; however, it did have considerable effect on the total weight of the chicks hatched. This is accounted for,

TABLE 8. Average Weight of Chicks When Hatched (grams).*

| Pen | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | Avg. |
|---|---|---|---|---|---|---|---|---|---|
| 1930-31 | | | | | | | | | |
| 1 | 29.6 | 38.4 | 35.9 | 34.5 | 36.5 | 36.9 | ____ | ____ | 34.6 |
| 2 | 30.4 | 34.9 | 34.0 | 33.3 | 34.9 | 33.4 | 34.4 | 32.0 | 33.7 |
| 3 | 31.2 | 34.5 | 36.1 | 35.3 | 36.8 | 35.8 | 35.2 | 35.5 | 34.9 |
| 4 | 29.3 | 35.5 | 34.5 | 34.3 | 35.3 | 35.0 | 32.9 | 32.8 | 34.0 |
| 5 | 30.8 | 35.2 | 35.7 | 35.6 | 36.7 | 36.7 | 36.1 | 35.3 | 35.4 |
| 6 | 29.2 | 33.7 | 35.9 | 36.3 | 36.0 | 33.9 | 35.1 | 33.9 | 34.6 |
| 1931-32 | | | | | | | | | |
| 1 | 33.6 | 36.1 | 36.3 | 36.8 | 39.9 | 37.5 | 37.0 | 34.5 | 36.6 |
| 2 | 33.2 | 33.9 | 35.4 | 36.7 | 38.9 | 35.7 | 33.8 | 31.8 | 35.1 |
| 3 | 33.1 | 35.0 | 37.7 | 37.2 | 38.2 | 37.2 | 35.3 | 34.5 | 36.5 |
| 4 | 32.1 | 34.5 | 35.8 | 38.4 | 38.9 | 36.8 | 35.6 | 32.0 | 35.6 |
| 5 | 32.3 | 35.2 | 34.7 | 37.3 | 38.6 | 36.3 | 35.9 | 34.4 | 35.9 |
| 6 | 31.0 | 34.4 | 34.1 | 35.8 | 36.8 | 33.5 | 34.2 | 32.8 | 34.2 |

*A few abnormal chicks were excluded from the averages.

of course, by the larger number of chicks hatched, as shown in tables 5 and 6. Cod liver oil did not increase the total weight of chicks when the pullets were allowed bluegrass range.

Benjamin(25) reported that there is a significant positive correlation between the size of the eggs incubated and the size of the respective chicks hatched. The data available in this experiment do not permit a comparison of individual chick weight with its respective egg weight. However, all eggs were pedigree hatched and data relating to chick growth will be given in a later publication. A comparison of average egg weight and average chick weight shows some relationship since in most cases the average weight of the chicks is highest in the months when average egg weight was highest.

## SUMMARY

1. In every case there was a decided increase in egg production as a result of the addition of two percent of cod liver oil to the mash. or of allowing the hens sunshine, bluegrass range or any combination of these supplements.
2. When pullets are confined to the house with no direct sunshine. except thru ordinary window glass, cod liver oil produces a decided increase in egg production.
3. Slight increases in egg production were noted when cod liver oil was added to the ration of pullets that received direct sunshine but no green feed.
4. The addition of cod liver oil did not result in much increase in egg production when used to supplement bluegrass range, except in one of the three winters (the coldest winter with the least sunshine).
5. Eggs from the pens receiving cod liver oil were slightly smaller than those from the corresponding pens receiving no oil.
6. Each vitamin D supplement increased the average hatchability above that of the pen confined without a vitamin D supplement.
7. Cod liver oil when added to the mash of confined pullets greatly improved hatchability; for those that received direct sunshine it slightly improved hatchability; and for those on bluegrass range its addition did not improve hatchability except during the coldest winter.
8. Under Kentucky conditions bluegrass range and sunshine provide ample supplements to the basal ration to assure high hatchability.

9. Cod liver oil in the mother hen's diet had little effect on the average weight of chicks at hatching time.

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